ON A METHOD OF PHOTOGRAPHING THE CORONA DURING A TOTAL ECLIPSE, BY WHICH EACH PART MAY BE GIVEN ANY EXPOSURE DESIRED ON THE SAME PHOTOGRAPHIC PLATE.

By CHARLES BURCKHALTER.

Within the last few years the corona has been so systematically photographed, and with instruments so dissimilar in aperture and focal length, that it may be considered as firmly established that no two parts of the corona, differing considerably in distance from the Moon's center, should receive equal exposure times—the extreme outer part requiring from twenty to one hundred times more exposure than that at the Moon's limb—and, on account of this wide range of exposure, no one negative has ever shown more than a comparatively small portion *properly* exposed. As a proof of this assertion, I need only call attention to two of the superb negatives made by Professor SCHAEBERLE, of the LICK Observatory Eclipse Expedition to Chili, in April, 1893, where, for the two in question, the exposures given were one-fourth second and thirty-two seconds, and, while the short exposure gave a negative showing a bewildering amount of detail within 10′ of the Moon's limb, not a vestige of the middle or outer corona appears; yet, in the long exposure, which shows it to a distance of about 3° from the Moon's center, there is no trace of the delicate detail so exquisitely shown in the quarter-second negative, it having been, as Professor SCHAEBERLE graphically expresses it, "burned out" by over-exposure. I take it for granted that all the above is so well understood by astronomers that argument is unnecessary. These negatives are on a grand scale (the Moon's image is 4.4 inches), and stand quite alone in their perfection, and, possibly, the present method reached its zenith with SCHAEBERLE'S triumph, although it must be admitted that, in the first example, the outer corona received only the 128th part of the proper exposure, and, therefore, is not shown at all, while in the latter, the inner corona, the most valued part, received 128 times too much.

A new method of photographing the corona is, then, it seems, a necessity, if we are to have anything more than properly ex-

posed fragments and the resultant "ideal" drawing; and this method, if it is to *completely* solve the problem, must be capable of giving the corona at the Moon's limb only one second or less exposure during the time the extreme outer parts, to the very limit of distance possible to photograph, are fully exposed, and, that too, at the same time, and upon the same plate.

I have recently completed a mechanical device by which any exposure desired can be made with great exactness, well within and beyond the requirements asked for above, providing the proper exposure time for the various distances from the Moon's limb can be approximately predicted, and, as astronomers now have such a great variety of negatives for comparison, this is at least possible.*

I expect to give this method a practical test in Japan at the eclipse of August 8, 1896. I shall be able to make at least four, and probably six exposures during the total phase (about $2^m\ 30^s$), and, as I can carry out any exposures desired (barring accident and unskillful work), I hope to obtain some good negatives. The correct exposure for this particular eclipse then is of the very greatest importance, and I hope to receive valuable suggestions from astronomers, giving me, for intervals of about 4′ outward from the Moon's limb to a distance of 108′ from the Moon's center, their ideas and judgment of a perfect exposure. Each exposure will be independent of all the others, and may be widely different; therefore, four to six ideal exposures can be tried.

The lens and tube of the photographic telescope I shall use are now being made by BRASHEAR, at the expense of a prominent member of the A. S. P., who will also provide a first-class equatorial mounting, with driving clock, etc. The lens will have an aperture of four inches, and focal length of fifteen feet, giving an image of the Moon about 1.7 inches. The plates will be twelve by twelve inches, and will permit controlling the exposure to about 108′ from the Moon's center.

At the present writing, while I have come to no definite conclusion, the following exposures have received some consideration, the exposures contemplated at the Moon's limb, and five

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* The apparatus was shown and explained by the writer at the meeting of the A. S. P., held at the LICK Observatory, June 8, 1895.

other points only being given, and in the probable order of exposure :

At Moon's limb.		At 26′	At 46′	At 66′	At 86′	At 108′
	s.	s.	s.	s.	s.	s.
A,	.4	.9	1.4	2.4	3.6	5.0
B,	.8	1.2	2.5	4.5	8.4	15.0
C,	.6	1.	3.3	7.2	15.9	30.0
D,	1.	4.	9.0	14.	20.	24.0
E,	1.5	1.8	2.6	3.9	6.2	10.0
F,	.3	.6	1.6	3.1	5.3	10.0

The apparatus for one negative is ready for the field (after an exposure has been decided upon) at the present time.

The apparatus would be difficult to describe, properly, without drawings, but the principle may be easily understood. Narrowed down to a few words, it consists of a diaphragm, properly shaped to give the required exposure, rapidly rotating close to, and immediately in front of the photographic plate, the movement being given by a driving-clock attached to the back and outside of the plate-holder, the arbor that carries the diaphragm passing from the driving-clock through a small hole in the middle of the plate, at the point that would ordinarily be occupied by the center of the Moon's image.

The shape of the diaphragm, which may be readily computed for any exposure, may be any one of several forms, but all take one of the various shapes of the cam.

The shape I have adopted is that of a double cam, one being inverted, and it is perfectly balanced without counter-weight, so that steady motion is assured. The driving-clock will run about fifteen minutes, and when newly wound, the diaphragm turns about five times a second, and so far as I can find, is entirely free from jar. The driving-clock starts automatically, a device having been added that promptly sets it in motion when the plate-holder is lifted by the hand to be placed in position in the telescope, thereby again narrowing the opportunity of making a failure. The holes in the plates I have for experiment are five-sixteenth of an inch, and the arbor that carries the diaphragm one-sixteenth. I do not consider the small hole in the plate as a serious objection, the Moon's image on the negative being clear glass, nor is the hole really necessary, for there are other ways of giving the required exposure without in any way changing the plate, and I

will briefly mention a few of the methods that I have considered, but I have pinned my faith to the one above described as being simple in the extreme, and as it has that *very* important feature, *perfect reliability*.

Where large images of the Moon are obtained, it can be done by suspending immediately in front of the plate, in the same manner as the "flat" in a Newtonian reflector is supported, a small and compact driving-clock to carry and turn the diaphragm; or, the clock and diaphragm could be held in position by a thin bar placed edgewise to the plate; or, the diaphragm alone could be supported by the bar and revolved by bevel gears driven by a clock outside the plate-holder. Either of these methods, however, would leave a very small portion of the plate unexposed (the part covered by the bar), which is an objection.

A small driving-clock with the diaphragm, could be attached to the plate itself, when the Moon's image is very large, so that no part of the corona would be cut off; but I can think of many objections to this method.

I spent some time upon a practical, but rather complicated device, consisting of a moving arm, working from a center behind the plate-holder, and in a line with its center, extending over to, and immediately in front of the plate, the motion to the diaphragm being given automatically by the motion of the arm across the plate by means of a cord wound upon a drum. The arm would be of flat steel, set edgewise to the plate and moving over an arc of 200 to 300 degrees. The parts of the plate swept over by the arm would get about a hundredth part less exposure than the other parts, but this small difference could be ignored.

My ideal device could only be used (without undue complications) with a photoheliograph, where the plate would be stationary and perpendicular, and the operator within the camera. It would consist principally of a ring in front of the plate, held in position by three or more guide-wheels, and rapidly rotated by a pinion; or, better, a belt from a wheel in the same plane. The center of the ring would be occupied by the center of the diaphragm, which would be attached to a cross-bar, held by two studs in the periphery, movable in two directions for precise adjustment.

A friend, to whom I explained my method, said: "The problem of exposing a *circular* corona, you have completely

COMET RORDAME, JULY 12, 1893.

$9^h\ 00^m$ — $10^h\ 12^m$ P. S. T.

Photographed by W. J. HUSSEY, at the LICK Observatory.

solved, but can you not give the faint polar regions more exposure than the bright equatorial streamers?" This can be done by placing somewhere between the source of power for driving the diaphragm and the diaphragm itself, two or more elliptical gear-wheels, which can be made to give a variable motion, giving the polar region from a small fraction to many times more exposure than that received by the equatorial parts. Another friend believes this ought not to be done, as we *want* this difference to show upon the plate.

I constructed a model, giving the polar regions twice the exposure received by the equator (in the same zones) and it is entirely reliable, but I do not expect to employ this feature at the coming eclipse. Finally, it should be said that my experiments have been conducted at the expense of a fund placed at the disposition of the LICK Observatory by Mrs. PHEBE HEARST, a member of this society.

CHABOT OBSERVATORY, Oakland, Cal., June, 1895.

A STUDY OF THE PHYSICAL CHARACTERISTICS OF COMET RORDAME.

By W. J. HUSSEY.

On the evening of July 8, 1893, Mr. ALFRED RORDAME, an amateur astronomer residing in Salt Lake City, discovered a bright comet in the constellation *Lynx*. He at once reported his discovery to the WARNER Observatory, and within a day or two the news had been communicated to astronomers throughout the world. The comet was discovered independently about the same time in many places. It had also been seen previously as a "hazy star," and even in the preceding month it had been observed by an amateur astronomer, who mistook it for another comet, already known.

For nearly two weeks it was a conspicuous object in the western sky during the early portion of the night. It was then at its greatest brilliancy, and, in most respects, in a very favorable situation for observation. It was near the Earth and near the Sun. On the day of its discovery it passed the point in its orbit nearest the Earth, at a distance of about 38,000,000 miles. On